CONTRIBUTION OF MUSKEG CHANNEL HABITATS TO JUVENILE COHO SALMON PRODUCTION IN THE SITUK RIVER, ALASKA.

By

Kevin L. Schaberg

RECOMMENDED: ______________________

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Nick Hughes

Advisory Committee Chair

WW Smoker

Chair, School of Fisheries and Ocean Sciences

APPROVED: ______________________

Dean, School of Fisheries and Ocean Sciences

Susan M Henrichs

Dean of the Graduate School

October 4, 2006

Date

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A THESIS

Presented to the Faculty
of the University of Alaska Fairbanks
in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

By

Kevin L. Schaberg

Fairbanks, Alaska

December 2006

Abstract

This study examines seasonal patters of habitat use by juvenile coho salmon in the Situk River and the importance of muskeg channels. To determine seasonal patterns I trapped fish from a range of habitats every two weeks during the summer of 2005. Analysis of the length-frequency data these samples provided showed most fry emerged in gravel bedded channels and that a substantial number of these fish then moved into muskeg channels during their first summer, rearing there until smolting at age 1+ or 2+. To estimate the number of coho salmon using muskeg channels, I established a relationship between channel width and fish density and scaled this up to the entire drainage using GIS analysis. This demonstrated that muskeg channels provide important rearing habitat. Comparison with published data suggests that muskegs are responsible for between 14% and 80% of total coho salmon smolt production in the Situk River.

Table of Contents

List of Figures

List of Tables

Acknowledgments

I would like to thank the field crews that helped collect the data for this project, Stephanie Mehalick, Jon Livermore, Matt Jones, Jasmine James, Howard Wiseman, Nate Catterson, Dan Gillikin, Matt Catterson, and Jennifer Hagen-Kane. They put in a lot of hours in all conditions to make this thesis possible. I would also like to thank my committee members, Dr. Nicholas Hughes, Dr. Mason Bryant, and Dr. Gordon Haas, for their ideas and support. The US Forest Service, Yakutat Ranger District provided the funding and logistical support to conduct this project.

INTRODUCTION

The Situk River in Southeast Alaska is one of the most productive coho salmon (*Oncorhynchus kisutch*) systems for its size in the Pacific Northwest according to Bradford et al. (1997). The Situk River is also the most productive steelhead trout (*Oncorhynchus mykiss*) stream in Alaska (Johnson and Jones 2000) and supports significant runs of five species of Pacific salmon, eulachon (*Thaleichthys pacificus*), and Dolly Varden (*Salvelinus malma*) (Table 1). The geology, climate, and hydrology provide the template for the high productivity of the watershed. Glacial outwash gravel and stable water flow provide abundant high quality spawning areas, while pristine and complex freshwater habitats provide excellent rearing habitat. The Situk also drains directly into one of the world's most productive marine habitats, the Northern Gulf of Alaska. The Alaska Coastal Current (ACC), one of the most productive rearing areas in the North Pacific Ocean for juvenile salmon (Myers et al. 2000), flows west past the mouth of the Situk estuary.

The proximity to this high quality marine habitat probably increases survival for the freshwater rearing species (Myers et al. 2000) and may be a factor in the evolution of ocean-type life histories for some species of the Situk. Coho salmon, sockeye salmon, and steelhead trout are the predominant species that utilize the freshwater habitats of the Situk River for rearing. Sockeye

Table 1. Estimates of adult returns and smolt production of the salmonids species utilizing the Situk River, Alaska. ([1]-compiled from ADF&G commercial and subsistence catches and weir and foot counts 1985-2005, [2] -Thedinga et al. 1993, [3] –Ericksen and McPherson 1997, [4] -Schaberg and Catterson foot counts, [5] -Pers. Comm. Gordy Woods)

Species	Adult	Smolt
chinook salmon	5,450[1]	67,000-80,000[2]
sockeye salmon	146,000[1]	701,000-893,000[2]
coho salmon	60,000[2]	612,000-1,197,000[3]
pink salmon	482,000[1]	3,907,000[2]
chum salmon	700[1]	83,000[2]
steelhead trout	8,200[1]	26,000[2]
eulachon	~1,000,000[4]	N/A
Dolly Varden charr	~100,000[5]	N/A
cutthroat trout	N/A	N/A
rainbow trout	N/A	N/A

salmon primarily use the headwater lakes as rearing habitat, whereas coho salmon and steelhead trout use the riverine portions of the system (Thedinga et. al 1993). The remaining species have significant proportions that display ocean-type juvenile life histories. Situk salmonids that display these characteristics include pink salmon and chum salmon, which are commonly associated with ocean-type life histories (Groot and Margolis 1991), whereas the majority of chinook salmon (98%) and a substantial fraction of the sockeye salmon (10-30%) (Thedinga et. al 1993) also display ocean-type life histories.

The purpose of this study is to investigate habitat characteristics that may contribute to the productivity of coho salmon in the system. When a river system is vastly more productive than other rivers of the same size, it must have some unique feature that contributes to this productivity. From observations of the Situk River watershed it appears that the muskegs adjacent to the Situk River and the dense network of channels draining these muskegs may provide this unique advantage. Muskeg channels provide an additional 102 km of available habitat in the Situk River watershed, doubling the available habitat.

Coho salmon use a broad range of habitat types throughout their freshwater life history, from mainstem to off-channel seasonally flooded habitats (Hartman 1965, Skeesick 1970, Bustard and Narver 1975, Bryant 1983, Hartman and Brown 1987, Brown and Hartman 1988, Swales and Levings 1989, Fausch 1993, and Giannico 2000).

Habitats in the Situk River watershed include riffle/pool complexes, debris pools and backwater habitat in the mainstem Situk River, headwater lakes, and beaver ponds. The most abundant habitat type is provided by the dense network of channels draining the vast muskegs of the area. Hartman and Brown (1987), and Brown and Hartman (1988) showed that coho salmon use seasonally accessible wetland habitats in British Columbia. The muskegs of the Situk River watershed retain water year round, though accessibility is limited during the driest periods of summer. During the fall rainy season, the muskeg channels overflow their banks and flood the entire muskeg. This provides access to even more seasonally available habitat, in the form of isolated ponds and ephemeral channels. It may even also allow migration between adjacent watersheds.

The objectives of this study are to identify patterns of juvenile coho salmon use of muskeg channels, and estimate population size of coho salmon in the muskegs. As part of this project I also develop a GIS model to predict channel type remotely from existing wetland spatial information.

METHODS

Study area

The Situk River is located near the village of Yakutat, Alaska on the northern coast of the Gulf of Alaska (Fig. 1). It flows south across the Yakutat Forelands, a glacial outwash plain lying between the mountains of the Brabazon Range to the north and the Gulf of Alaska to the south. One of the most important hydrological features of these glacial deposits is that they contain layers of fine sands and silts that have limited permeability. As a result most of the area has poor drainage. This coupled with the low relief (<60 m), high rainfall (approximately 3.8 m per year), and water from springs and seeps, has fostered the development of extensive marshes and muskegs (Shepard and Brock 2002). More well drained areas are dominated by spruce forests. Most of the landscape can be characterized as either forested or muskeg vegetation types.

The Situk River originates from two headwater lakes (Situk and Mountain Lakes, combined surface area 5 km^2) and has a drainage area of 200 km^2, the main-stem Situk River is 35 km long with an average width of 20 m and a mean annual discharge of 10.2 $m^3 s^{-1}$. The climate is cool maritime, with a mean annual temperature of 3.9°C, and a mean annual rainfall of 3.8 m y^{-1} (National Weather Service data). The main-stem Situk River and its larger tributaries, West Fork

Figure 1. Location of the Yakutat Alaska showing the Situk River (black), and the channel densities associated with the Forelands (gray).

Situk River and Old Situk River, have gravel-bedded channels, with a distinguishable flood plain, 2-5% gradient, small gravel to large cobble substrate, well developed riffle-pool sequences, and numerous accumulations of large woody debris. These channels are typically surrounded by forested riparian stands dominated by Sitka spruce (*Picea sitchensis*) with understories of blueberry-devils club (*Vaccinium-Echinopanax horridum*).

Approximately sixteen tributaries draining the extensive muskegs of the watershed also feed the Situk River. These muskeg channels have low gradients (<2%), steeply incised banks, tannin stained water, and little in-stream structure. Both the stream banks and the streambed are composed of fine organic materials. The riparian vegetation is composed mostly of barclay willow (Salix barclayi), Sitka alder (*Alnus sinuata*), bog cranberry (*Oxycoccus palustris*), and sedges (*Carix spp.*).

The six gravel-bedded sample sites were chosen to represent a variety of channel widths (4-20m) and both upstream and downstream proximity to the muskeg channels sampled (Figure 2). Sites were located on the mainstem Situk River (2), West Fork Situk River (2), Old Situk River (1), and one small tributary to the West Fork Situk. All the sample sites displayed the characteristics common to gravel-bedded channels; forested riparian areas, in-stream woody debris, riffle-pool sequences, identifiable flood plains, and gravel dominated substrates.

Figure 2. The Situk River watershed with length frequency sample locations, gravel bedded (■) and muskeg (▲). Density estimates were conducted in the same muskeg channels.

The three muskeg sites were located in a muskeg west of the Situk River about 13 km upstream from its entrance to the estuary. One site was selected in each of three channel width classes, large (>3m), medium (1-3m), and small (<1m). The channels were all directly linked to one another below the sample reaches. All three channels had steeply incised organic banks, minimal in-stream wood, tannin colored water, little flow, and organic substrate.

Sampling Design

Fish in both channel types were sampled bi-monthly from May to September 2005 to determine length frequency and age distribution. For these samples, each site was sampled by fishing five 1/8" mesh minnow traps, baited with salmon roe, for one hour. Fish were anesthetized using MS-222, identified to species, fork length was measured to the nearest mm, and fish were weighed to the nearest 0.01g. Fish were then revived and released at the site of capture.

Density estimates were conducted in the muskeg channels, but not in the gravel bedded channels. I used depletion estimates described by Bryant (2000) to estimate fish density in each muskeg channel during August 2004. This involved block-netting a 60 m^2 reach in each channel with a fine meshed net, and saturating the area with baited minnow traps at a density of one trap per square meter. The traps were fished for four consecutive 90-minute periods, or until there were three successive decreases in catch. Fish were processed as described above and retained outside the sample reach until sampling was complete.

Analysis

For analysis of length distributions I pooled data on coho salmon by the two channel types and sample date. For each date I constructed proportional length frequency distributions, and identified separate modes representing age classes. Age classes represented fish that emerged that spring (age 0), and fish that over-wintered at least one year (age 1+). Inferences about seasonal age-specific habitat use were made using the age composition and length frequency data.

To obtain estimates of the number of fish in each age class (age 0 or 1+) utilizing muskeg channels, I constructed length frequency distributions from the depletion data to identify the distinct modes representing each age class, and then counted the number of fish in each age class captured during each 90 min sample period. I then estimated the abundance of fish of each age class in the sampled reach using the capture program (White et al. 1982). These estimates were then divided by the length of the sample reach (20 m for the large channel, and 60 m for medium and small channels) to obtain densities of fish per linear meter. This density was then applied to the amount of available habitat of each width class obtained from the stream network that had been run through a channel type prediction model created in GIS.

GIS Model Development

To estimate the number of age 0 and 1+ coho salmon in all the muskeg channels of the Situk River watershed during August 2004, I first built a GIS model that differentiated muskeg channel habitats from gravel-bedded channel habitats based on surrounding vegetation type. Data needed to construct a GIS model to predict channel types remotely from existing land characteristic maps was collected from100 channels across the forelands providing information on riparian habitat types and verified channel types for muskeg and gravel-bedded channels. These data points were overlaid onto existing GIS maps of vegetation, soil, geologic, and wetland habitat types. The descriptive attribute of each of the maps that corresponded with the location of the verified channels was used in a Kruskal-Wallace non-parametric test (α=0.2). This test produced the map source that had >80% accuracy in predicting channel type from a spatial attribute. The simplicity of the Yakutat Forelands landscape allowed me to expand these predictions to similar habitat types adjacent to those predicted by the K-W results. The predicted channel type was then attributed to the habitat types associated with it.

Channels were then digitized using 1 m resolution 4-band near infrared satellite imagery. The predictor model was applied to these channels by creating a point grid of the channel network and attributing the channel grid with the channel type for each 1 m section of channel. Muskeg channels were then placed into width classes'; large (>3m), medium (1-3m), and small (<1m), based on observable width and verified with on the ground measurements. I then calculated the total length of each size class of muskeg channel in the Situk River watershed and used my estimates of the number of fish per unit length for each channel size-class to obtain estimates of the total number of coho salmon utilizing each channel size. I then summed the estimates for all channel size-classes to estimate the abundance of age 0 and 1+ coho salmon in all the muskeg channels of the Situk River watershed during August of 2004.

To give some idea of the contribution of muskeg tributaries to total coho salmon production in the Situk River I applied survival rates to the number of 1+ coho salmon inhabiting the muskeg channels in 2004 (see Figure 3). Since there are no estimates of parr to smolt survival for the muskegs channels, I applied published parr to smolt survival rates representing high survival through low survival (0.096 and 0.007 from Godfrey 1965, 0.073 from Fraser et al. 1983, and 0.31 and 0.25 from Reeves et al. 1989).

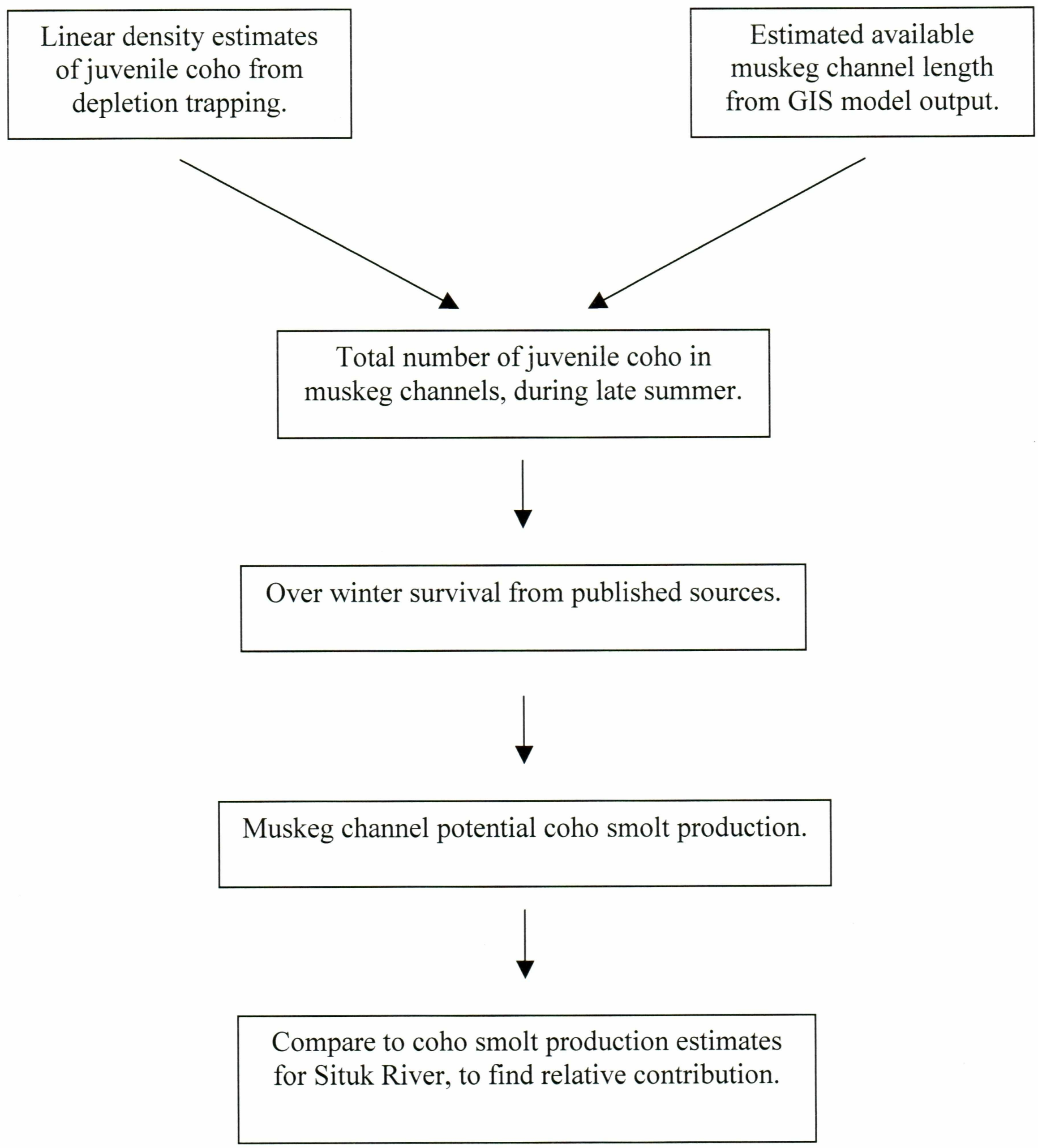

Figure 3. Flow chart showing the steps in the estimation of relative contributions to coho production of the muskeg channels of the Situk River watershed.

RESULTS

Patterns of Habitat Use

Coho salmon were captured in muskeg channels on every sample occasion. Age composition, identified from length frequency plots (Figure 4), shows the initial compositions in each habitat are dominated by a single age class, gravel bedded channels are dominated by age 0 coho salmon and muskeg channels are dominated by age 1+ coho salmon (Table 2). Age 0 coho salmon continue to dominate composition in the gravel bedded channels throughout most of the summer, while the age composition becomes more even in the muskeg channels during the middle of the summer. Age 1+ coho salmon then regain a majority later in the summer, while composition in the gravel bedded channels becomes more even later in the summer.

Importance of Muskeg Channels

Linear density estimates (coho m^{-1}) of age 0 and 1+ coho salmon in each of the three channel size categories returned estimates of 3.2 age 0 and 12.7 age 1+ coho salmon m^{-1} for the large muskeg channel, 1.28 and 3.3 coho salmon m^{-1} for age 0 and age 1+ fish respectively in medium channels, and 1 and 1.32 coho salmon m^{-1} for age 0 and age 1+ fish respectively in the small channel (Table 3).

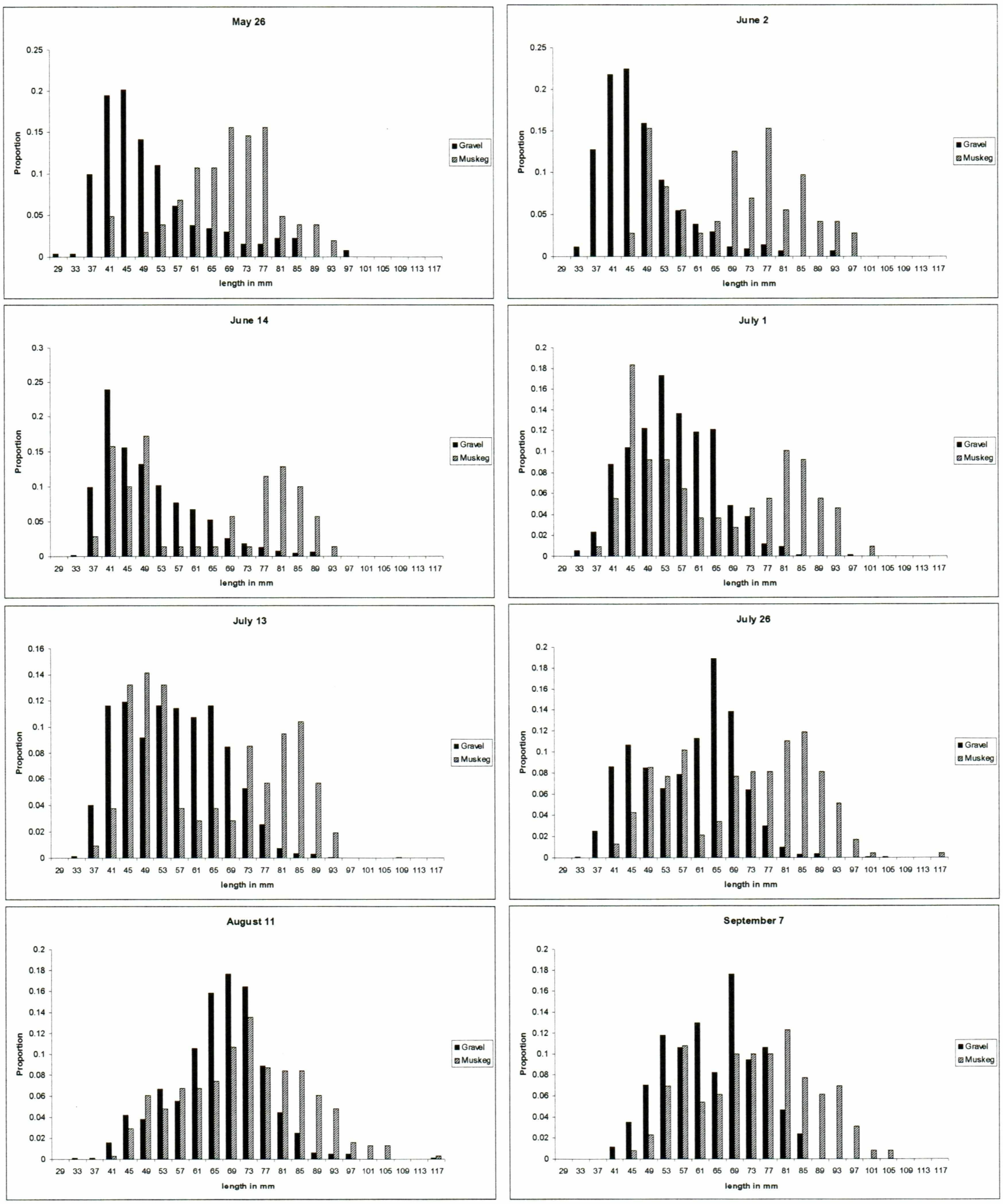

Figure 4. Proportional length frequencies for juvenile coho salmon of the Situk River watershed, in gravel bedded (black) and muskeg (hashed) channel types throughout the summer of 2005.

Table 2. Age composition of coho salmon estimated from length frequency histograms for gravel bedded and muskeg channels of the Situk River watershed over the summer of 2005.

Date	Gravel bed		Cutoff length	Muskeg	
	0	1+	age 0 (mm)	0	1+
26-May	75.29%	24.71%	53	11.65%	88.35%
2-Jun	82.99%	17.01%	53	26.39%	73.61%
14-Jun	80.46%	19.54%	57	48.57%	51.43%
1-Jul	65.09%	34.91%	57	49.54%	50.46%
13-Jul	70.61%	29.39%	61	51.89%	48.11%
26-Jul	55.97%	44.03%	61	34.04%	65.96%
11-Aug	48.40%	51.60%	65	35.05%	64.95%
7-Sep	55.29%	44.71%	65	32.31%	67.69%

Table 3. Available muskeg habitat calculated from GIS channel type prediction model, linear densities of coho salmon calculated from depletion estimates, and potential abundance of coho salmon in the muskeg channels as a product of linear density and available habitat.

Channel size	length	densities m^{-1}		coho potential		
	(m)	0+	1+	0+	1+	
large (>3m)	42,490	3.20	12.70	135,968	539,623	
medium (1-3m)	33,103	1.28	3.30	42,482	109,240	
small (<1m)	25,551	1.00	1.32	25,551	33,642	
Total	**101,144**			**204,001**	**682,505**	**886,506**

The channel type prediction model (Figure 5) was applied to the digitized streams layer (Figure 1) resulting in estimates of 42,490 m of large muskeg channel (> 3 m width), 33,103 m of medium muskeg channel (1-3 m width), and 25,551 m of small muskeg channel (<1 m width) (Table 3). Linear density extrapolation resulted in estimates of 204,001 age 0 and 682,505 age 1+ coho salmon in the muskeg channels of the Situk drainage during August 2004. Application of published survival rates to this age 1+ coho salmon estimate resulted in smolt production estimates ranging from 4,778 to 211,577 for all muskeg channels of the Situk River watershed (Table 4). Using the 25% survival rate estimate (170,626) compared to a range of Situk smolt estimates produced a range of muskeg contributions to total Situk River coho salmon smolt production from 14.25% to 80.11% (Table 5).

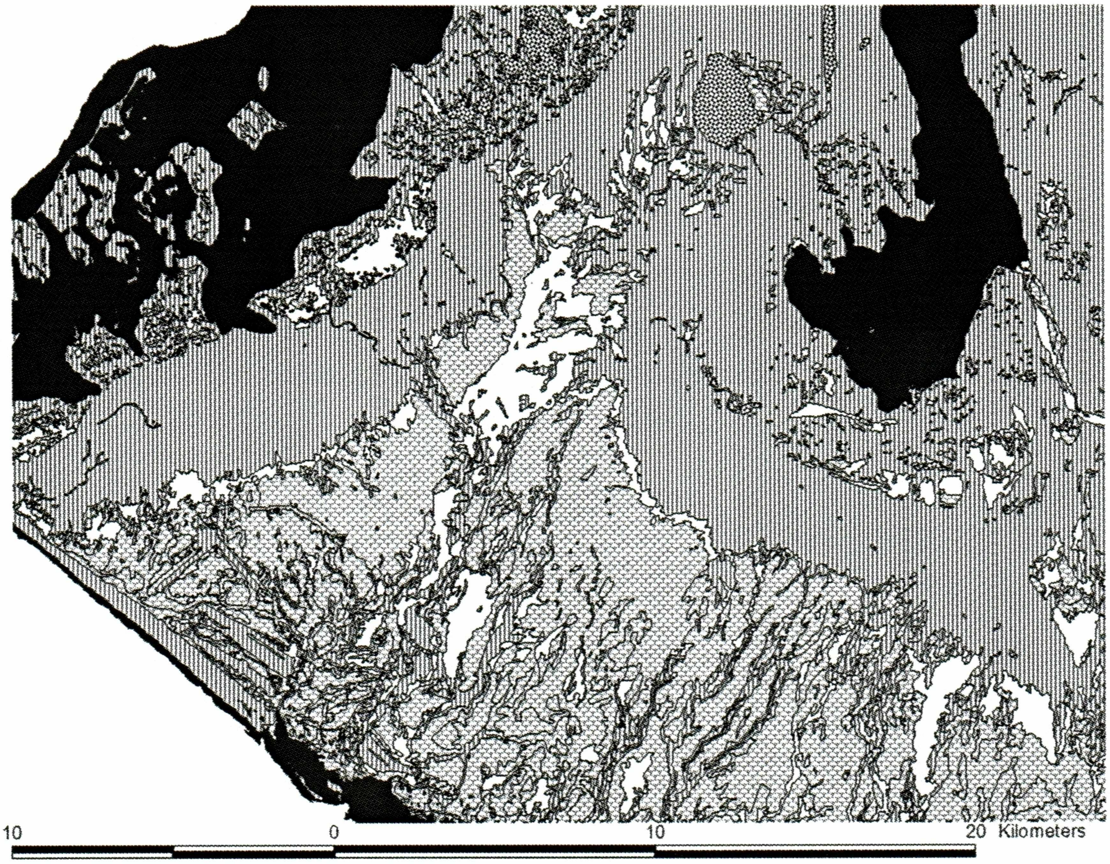

Figure 5. Results of GIS prediction model. Muskeg channels are predicted to flow through areas indicated by lighter stippling, gravel bedded channels are predicted to flow through areas indicated by dark hashing. White indicates inadequate (<80%) confidence for predicting channel type.

Table 4. Muskeg channel coho salmon smolt production estimates obtained by applying published 1+ - smolt survival rates to estimates of age 1+ coho salmon abundance (682,505) in the muskeg channels of the Situk River watershed.

Survival	Coho salmon smolt production	Reference
31.0%	211,577	Reeves et al. 1989
25.0%	170,626	Reeves et al. 1989
9.7%	65,862	Godfrey 1965
7.3%	49,823	Fraser et al. 1983
0.7%	4,778	Godfrey 1965

Table 5. Estimates of the proportion of Situk River coho salmon smolt production that can be attributed to muskeg channels assuming that 170,626 smolt are produced in the muskeg channels (25% 1+-smolt survival, see Table 4.) and calculated using three published estimates of coho salmon smolt production for the entire Situk River.

Situk smolt estimates	Proportion of Situk smolt from muskegs	Situk smolt estimate sources
213,000	80.11%	Thedinga et al. 1993
612,000	27.88%	Ericksen and McPherson 1997
1,197,000	14.25%	Ericksen and McPherson 1997

Discussion

This study identified the muskeg channels of the Situk River as important rearing habitat for coho salmon throughout the summer and suggests they probably provide over winter habitat as well. This is significant when the freshwater life history is examined. The dominance of age 0 coho salmon in the gravel bedded channels through the first half of the study period and the relative lack of age 1+ coho salmon verify that nearly all of the spawning occurs in the gravel bedded channels, and that few age 1+ coho salmon utilize the mainstem habitats for rearing during the summer. The lack of spawning habitat in the muskeg channels, and the appearance of age 0 coho salmon, suggests that age 0 fish move into the muskeg channels. Although migration was not measured directly using marked fish or weirs, changes in age composition and size structure suggest that age 0 coho salmon move into and remain in the muskeg channels. This migration may have started before the first sample period, as there are age 0 fish identified in the muskeg channels in the initial sample. The presence of proportionally dominant age 1+ coho salmon in the muskeg channels during the initial period, and their consistency in the muskeg channels throughout the study, particularly the last period, suggest over wintering.

Observations through the winter months reveal very few juvenile salmonids in the gravel bedded habitats. These observations together with the findings here of little main-stem rearing by age 1+ coho salmon suggest that after age 0 coho salmon migrate to the muskeg channels over the course of the summer, they may remain there and over winter. While this immigration to small tributaries has been documented (Skeesick 1970, Bustard and Narver 1975, Bramblett et al. 2002), most of these studies show an emigration the following spring. This raises some interesting questions regarding the suitability of the main-stem habitats for rearing. The main-stem Situk River has an abundance of classic rearing habitats, deep pools with lots of wood, overhanging vegetation, and backwater areas. The presence of these habitats, the marine derived nutrients supplied by returning adults, and the coho salmon production of the system would suggest that the main-stem habitats provide excellent rearing areas. Therefore there must be a benefit for the fish to move away from this apparently acceptable rearing habitat. The emigration from the main-stem habitats is probably due to two main factors, avoidance of high flow events and predator avoidance.

Skeesick (1970) reported a migration of coho salmon into Spring Creek in Oregon and suggested that this migration may be explained by avoidance of high flow periods of the main-stem river. High flows during the fall and winter are very common in the Situk River. During this study the peak discharge was ~1600 CFS at the end of August, and water levels rose to over 2900 CFS in early January (USGS data). The turbidity and high flows would decrease feeding success while increasing energy output required to maintain position. When the Situk River is at flood stages muskeg channels also flood. By migrating to the muskeg channels to avoid high water, coho salmon are able to utilize this high water to their benefit. The entire muskeg becomes flooded becoming a large shallow pond, which allows fish to swim over normally "dry" land and feed. It also allows fish to move to other channels and access non-system ponds, and may allow fish to access entirely different watersheds.

It is well documented that coho salmon utilize off channel habitats (Lister and Genoe 1970; Quinn and Peterson 1996; Kahler et al. 2001). The movement suggested by this study may be attributed to the traits described by Quinn and Peterson (1996) who documented that high quality coho salmon habitat associated with wetland channels resulted in increased overwinter survival and larger smolt size. Off channel habitats in the form of beaver ponds have been identified as important coho salmon habitat (Bryant 1983; Pollock et al. 2004). Bryant (1983) and Pollock et al. (2004) also found that beaver pond habitats can increase survival and growth. Due to the nature of the muskeg channels functioning as both wetland channels and beaver ponds, a higher survival rate can be expected. If this is the case, then a larger portion of coho salmon produced by the Situk River coho may be attributed to muskeg channels.

Predator avoidance may also be a cause of this migration to muskeg channels. Many studies have shown habitat shifts caused by the presence of a predator (Fraser and Cerri 1982, Werner et al. 1983, Power 1984, Gilliam and Fraser 1987, Fraser et al. 1995). The appearance of Dolly Varden charr in the Situk River to feed on salmon eggs and carcasses may motivate coho salmon to move away from the mainstem. The timing of their appearance coincides with the initiation of decreasing catch rates of coho salmon in the gravel bedded channels, and increasing coho salmon catch rates in the muskeg channels (Figure 5). This presents a template for another interesting situation. It appears that juvenile coho salmon are not utilizing the abundant resources provided by returning spawners, but avoiding it to decrease risk of predation by large Dolly Varden charr.

It follows that muskeg channels not only provide refuge from predators but also adequate food sources. According to ideal free distribution (Fretwell and Lucas, 1970 Fretwell 1972) an individual should select the habitat that will provide the highest increase in fitness. When selecting a habitat in the Situk watershed, a juvenile coho salmon has two choices; 1) Gravel bedded channels have abundant food sources (++), lots of predators (-), high flow events (-), and good habitats (+), and 2) Muskeg channels have stable flows (+), few predators (+), good habitats (+), access to open muskegs during high water (+), but food sources are not quantified. Just looking at this simple plus minus scale, it can be seen the muskeg channels (+4) have many advantages, apparently enough to outweigh some of the major advantages in the gravel bedded channels (+1).

This apparent migration allows coho salmon to take advantage of both the excellent spawning habitats available in the gravel-bedded channels and the large supply of high-quality rearing habitats in the muskeg channels. Together these habitats work together as incubators and nurseries to provide the outstanding conditions that allow for the extremely high production of coho salmon smolt. The adjacent highly productive ocean habitat then provides excellent conditions for these smolt to complete their life cycle.

The 102 km habitat provided by muskeg channels is a substantial addition to the 100 km of gravel bedded channel in the drainage, and this, plus the suitability of these channels as coho salmon habitat, almost certainly explains why Bradford et al. (1997) found that the Situk River may be the most productive coho salmon system for its size in the Pacific Northwest. However, Bradford et al. (1997) only used main-stem length and headwater lake perimeters for the length of habitat attributed to coho production. With the inclusion of all the muskeg habitats and the main gravel bedded tributaries (202 km), excluding the lake habitats, the amount of available habitat is more than twice the 96 km used by Bradford et al. (1997). This would reduce the position of the Situk in his ranking of coho production per km of habitat. Another note as to Bradford et al.'s quantification is the value he used for coho salmon smolt production. Bradford et al. (1997) used smolt production estimates from Thedinga et al. (1993) of 213,000. This number is extremely low compared to estimates from Ericksen and McPherson (1997) which ranged from 612,000 to 1,197,000 and estimates from Shaul (2006 pers. comm.) of 1,089,000 coho salmon smolt from the Situk River . The use of these numbers would most definitely place the Situk River at the top of Bradford et al.'s (1997) ranking.

The range of smolt estimates from Ericksen and McPherson (1997) are based on two different procedures. The low estimate, 612,000, is based on in-stream juvenile mark recapture, while the upper estimate, 1,197,000, is based on coded wire tag data on marked smolt and returning adults. Shaul (2006 pers. comm.) estimated smolt production (1,089,000) using marked smolt and adult return method, wheras Thedinga et al. (1993) used instream mark recapture for their estimates of 213,000. The discrepancy between the in-stream and adult methods may be attributed to the use of the muskeg channels.

If smolt production estimates from the muskeg channels in this study are compared to the smolt estimates from Thedinga et al. (1993) and Ericksen and McPherson (1997), there is a considerable range in the proportion of coho salmon production attributed to the muskeg channels (Table 5). Since there are no solid estimates of coho salmon smolt production from the Situk River, and there are no estimates for over winter survival for muskeg channels, these values are speculative, however the results illustrate that the muskeg channels provide significant rearing areas for juvenile coho salmon.

Muskeg channels are fragile and very susceptible to human damage. Thin layers of clay are responsible for creating the perched water tables that support the development of muskegs (Shepard and Brock 2002), and these can easily be punctured by human activities such as road building and all-terrain-vehicle operation. When this happens it can effectively remove the plug from the muskeg and drain both the channels and the wetland. The ruts formed by off-road vehicles also change the drainage network and if a trail network becomes dense enough, it can route water out of the muskeg, draining the wetland and drying up the channels. The contribution these channels have to the coho salmon production in the Situk shows how critical this habitat is to the proliferation of the species.

Wetlands are only recently being associated with salmon habitat. This study shows that muskegs function as an important habitat for juvenile coho salmon rearing and over wintering. The density of channels associated with the muskegs in this study show that massive areas are not needed to provide abundant salmon habitat. Although the densities in the Situk watershed are high, other areas of the Yakutat Forelands have densities of muskeg channel 3-4 times higher (Figure 1). The preservation of this habitat is crucial to the preservation of the purely wild runs of coho in the Situk River, and may provide information for habitat restoration possibilities otherwise not yet considered.

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